*Biological Forum – An International Journal* **15(9): 392-396(2023)**

**ISSN No. (Print): 0975-1130**
**ISSN No. (Online): 2249-3239**

# Characterization of Soils under Zabo Farming System of Nagaland

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*(Received: 27 June 2023; Revised: 25 July 2023; Accepted: 27 August 2023; Published: 15 September 2023)*
*(Published by Research Trend)*

**ABSTRACT: Long-term usage of a certain land use system may alter the physico-chemical characteristics of the soil, changing its soil quality and nutrient availability to crops. Keeping this in view, an investigation was carried out to assess the physico-chemical properties and nutrient availability status under Zabo farming system, an indigenous farming systems practiced by the Naga tribe in Nagaland. Three villages from Phek district of Nagaland where farmers are practicing Zabo farming system were selected. From each village, 3 sites i.e. terrace, valley and hilltop forest as a reference were selected and from each sites, one composite soil sample (0-15 cm) were collected. The soil samples were analyzed for various physico-chemical properties. For group comparison among 3 villages and 3 forest sites, non-parametric Kruskal-Wallis H-test incorporating Monte-Carlo significance test at 95% confidence limit was used. The result revealed that bulk density (0.80-0.85), particle density (1.1-1.6), MWHC (62-66%) were higher in cultivated soil (terrace and valley) of Zabo system than the hilltop forest soil. The soil under Zabo farming system was found to be acidic in reaction (pH 4.3-5.6) and high in organic matter (2.2-3.6%). The available N (330-365 kg/ha), P (23-33 kg/ha) and K (255-285 kg/ha) were higher in cultivated soil i.e. terrace and valley soils, compared to hilltop forest soil under Zabo farming system.**

**Keyword:** Zabo farming system, soil physico-chemical characteristics, nutrient availability, Nagaland.

## INTRODUCTION

Traditional agriculture is often considered a step between the local hunt-and-gather practice, which provides communities with subsistence levels of food, and the practices of modern agriculture, used for mass-production of food for global distribution. This traditional agriculture practice develops a balance between meeting our present needs, conserving natural resources, and protecting the environment for the benefit of future generations. Traditional agricultural approaches are not practical for mass food production, but accounts for a substantial amount of local food production in the developing world. The farmers of North-East India rely on a variety of agricultural practices, including a variety of sedentary systems, such as wet-rice cultivation, fallow systems, shifting cultivation, home gardens, etc. (Ramakrishna, 1992; Sanjay-Swami, 2021). In Nagaland, a highly scientific approach for combining various crops, livestock, and fisheries is used which is known as Zabo farming system. The word 'Zabo' is derived from the Chakhesang word 'zabö' which means 'impounding runoff water.' In certain other areas, Zabo is sometimes referred to as the Dzüdü or Ruza system. It combines forestry with horticulture, agriculture, fisheries, and animal husbandry and has a strong foundation in soil and water conservation. The system, created by smart and skilled tribal people, is so exceptional in the development and administration of water resources that even contemporary approaches appear to be no match for it. It is now practiced in many Chakhesang tribe inhabited areas of Phek district. Even though the Kikruma region of the Phek receives sufficient rainfall, people there experience a water shortage because of surface runoff. Due to the lack of water, they were obliged to develop a complex system of water gathering, which gave rise to Zabo farming system (Sanjay-Swami *et al.*, 2021).

Zabo farming system is a magnificent planning of harvest runoff water and cultivate which has been practicing over a decade ago. But the properties of the soil, the dynamics of the nutrient cycle, and soil fertility are unknown which may harm the ecological balance (Sanjay-Swami, 2020a). Long-term usage of a certain land use system may alter the physico-chemical characteristics of the soil, changing its fertility status and nutrient availability to plants (Tsanglao *et al.*, 2014). One of the key environmental elements that might affect plant growth and severely restrict crop growth and production is soil acidity. In hilly states like Nagaland, the issue of soil acidity is particularly serious and is acknowledged as a significant agricultural issue (Mishra, 2004). Plant growth, development, and yield are significantly influenced by the nutrient condition of the soil, and knowledge of that status can help with planning effective nutrients usage and soil management techniques. The inherent capacity of soil to provide essential plant nutrients for absorption by crops is made easier with knowledge about the status of the soil's nutrient resources (Sanjay-Swami, 2020b; Yumnam and Sanjay-Swami 2022). However, scanty information is available on physico-chemical properties, nutrient availability status of Zabo farming system being practiced in Phek district of Nagaland. Therefore, the present investigation was carried out to assess the soil characteristics and nutrient availability status in Zabo farming system.

**Study area.** Zabo farming system is now practiced in many Chakhesang tribe inhabited areas of Phek district. Phek district is located in the south-eastern part of Nagaland (Fig. 1). It is bounded between 94°11′ and 95° East Longitudes and 25°28′ and 26° North Latitudes. The name of the district headquarters is also Phek. The district is bounded by Myanmar in the East, Zunheboto and Tuensang districts in the North, Manipur state in the South and Kohima district of Nagaland in the West. The main tribes of the district are "Chakhesangs" and "Pochurys". The district enjoys a humid sub-tropical climate. It receives southwest monsoon with annual average rainfall of 1,527 mm. The maximum rainfall occurs during the months of June and July. Rainfall generally begins from April and continues till the end of September. The area enjoys a cold winter and mild summer.

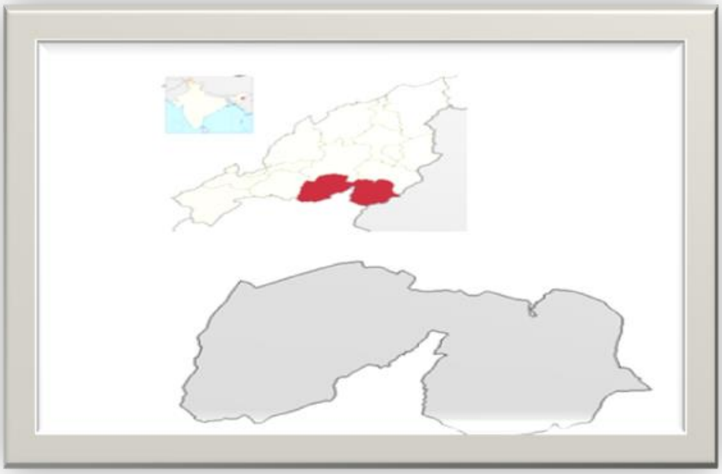

**Fig. 1.** Study area.

Physiographically, the district is mostly occupied by NE-SW trending hill ranges, with limited intermountain valleys. The average mean temperature is 25-30°C during summer and the temperature fall even to around 0°C during peak winter in some place. In winter season occasionally the district enjoys snow fall also. The landscape is mostly covered with closed to open broadleaved evergreen or semi deciduous forests. Agriculture is the main occupation with 80.84 % of the population engaged in agriculture. The total cropped area of the district is 27500 ha (inclusive of fruit crops) however the net area sown is 25521 ha with net irrigated area of 12700 ha.

## MATERIALS AND METHODS

The present study was conducted during 2022-23 to assess various soil characteristics and nutrient availability status under cultivated (terrace and valley) and hilltop forest soil (0-15 cm) under Zabo farming system. Three villages from the Phek district were selected for soil sampling. One composite soil sample from cultivated area and one sample from the hilltop forest soil were collected from each selected village. Collected soil samples were analyzed for bulk density, particle density, maximum water holding capacity, pH, cation exchange capacity, organic carbon, available N and available P and available K. Bulk density, particle density and maximum water holding capacity were determined by Keen Raczkowski Box method (Baruah and Borthakur 1999) and values are expressed in g $cc^{-1}$. The pH of the wet soil samples was determined in 1:2.5 soil water suspension, potentiometrically measured using a pH meter (Page *et al.*, 1982). Soil organic carbon (SOC) was determined by wet digestion method (Walkley and Black, 1934). In which the dry 2 mm passed soil sample was powdered using pestle and mortar to pass through 0.2 mm sieve. A known weight of powdered sample was treated with known volume of standard $K_2Cr_2O_7$ and concentrated $H_2SO_4$. The unused $K_2Cr_2O_7$ was quantified by back titration with standard ferrous ammonium sulphate using ferroin indicator. CEC was determined by 1N ammonium acetate extract followed by filtration method which is given by Page *et al.* (1982). Available nitrogen was estimated by alkaline $KMnO_4$ method. 5 grams of 2 mm sieved soil was distilled with 25 ml of 0.32% alkaline potassium permanganate solution in the presence of 25 ml of 2.5% sodium hydroxide (NaOH) solution in 300 ml distillation tube using N distillation system. The liberated ammonia collected in boric acid mixed indicator solution was titrated against 0.02 N $H_2SO_4$ to estimate available N by Subbaih and Asija (1956). Available P in soil was determined by following the stannous chloride blue colour method (Bray and Krutz 1945; Page *et al.*, 1982). Finely grinded air dried soil (5 gm) was extracted with 50 ml of 0.03N $NH_4F$ in 0.025N HCL for 5 min in a reciprocating shaker. After shaking the soil suspension was filtered through Whatman No. 42. 5 ml of the supernatant was taken for developing blue colour by adding 5 ml of Dickman Bray's reagent and 1 ml stannous chloride. Finally, intensity of blue colour was measured at 660 nm and concentration of P was obtained from the standard curve. Available phosphorus was expressed as kg $ha^{-1}$. Available potassium was analyzed by Hanway and Heidal (1952) method wherein 5 gram of 2 mm sieved soil was shaken with 25 ml of neutral normal ammonium acetate solution for 5 minutes and filtered through Whatman No. 42 filter paper. The extract was analyzed for sodium and potassium using flame photometer (Hanway and Heidal 1952). Values of soil attributes were analyzed by SPSS (v.01) for group comparison using non-parametric Kruskal-Wallis H test incorporating Monte-Carlo significant test at 95% confidence limit.

## RESULTS AND DISCUSSION

*A. Physico-chemical properties*

The results of physico-chemical properties revealed that bulk density (BD), particle density (PD), maximum water holding capacity (MWHC) were higher in cultivated soil (terrace and valley) of Zabo system than the hilltop forest soil which was used as a reference soil (Table 1). Bulk density varies due to management practices such as integrated nutrient management (INM) resulting in the lower bulk density of 1.03 Mg $m^{-3}$. This corroborate with the findings of Saha *et al.* (2010). Particle density ranged from 1.10-1.60 g/cc in cultivated soil of Zabo farming system. This is in agreements with the results obtained by Abbasi *et al.* (2009). The use of organic inputs such as crop residues and manures has great potential for improving soil productivity and crop yield through improvement of the soil physical properties and nutrient supply (Sanjay-Swami *et al.*, 2020). The lower BD, PD, MWHC values in the forest soils were owing to increased organic matter content in the forest site (Saha *et al*., 2011; Mishra *et al*., 2021) in comparison to the cultivated site.

The soils under cultivated areas of Zabo farming system showed slightly high pH as compared to forest land (Table 2). Soils are acidic in reaction due to leaching of base from the exchange complex under the prevailing high rainfall and hilly topography, highly acidic soils of the states pose a great challenge due to incidence of crop root damages due to high concentration of iron ($Fe^{+2}$) and aluminium ($Al^{+3}$) which also inhibit absorption of $Ca^{+2}$ and $Mg^{+2}$ and thereby soil biological health is adversely affected due to dominance of fungi in the acid soil (Sharma *et al.*, 2015; Poji *et al.*, 2017; Sanjay-Swami and Singh, 2020; Sanjay-Swami**,** 2020c). The soils of most of the North Eastern states of India are acidic in reaction (Yadav and Sanjay-Swami 2019). Arunachal Pradesh, Assam, Manipur, Mizoram, Meghalaya, Nagaland, Tripura and Sikkim have almost entire area (more than 95%) under acidic soils (Sharma and Singh 2002; Yadav *et al.*, 2020). The cation exchange capacity ranged from 7.00 to 20.00 cmol (p)+ $kg^{-1}$ in cultivated soil of Zabo farming system which is lower in comparison to forest soil (Table 2). The soils under forest ecosystem indicated higher CEC value than other ecosystems which might be due to high amount of organic carbon in the soils under forest ecosystem. It might be due to differences in mineral composition, clay concentration, pH, and organic carbon content of soils. Possible explanation for these results was that higher organic matter content in the forest soils might be cause of higher CEC.. Low CEC of these soils might be described due to presence of low CEC clay minerals *viz;* Kaolinite and Illite dominantly in the soils of North Eastern states of India (Dey and Sehgal 1997). Lower CEC values of the soils of Nagaland have also been reported by Patton *et al.* (2007).

The result obtained in this study demonstrated higher SOC contents in the soil (Table 2). In Zabo farming system, paddy is cultivated below livestock area at the foothills. Paddy fields get organic manure from livestock and the water structure of Zabo system at the upper elevation is used for livestock and irrigation purpose in the paddy cultivation. Before applying the water from the main pond to paddy fields, it is passed through the cattle enclosures so that it carries the dung and urine of animals to the paddy fields (Singh, 2007; Sanjay-Swami, 2021). This serves as a good source of nutrients for the paddy crops. The plant roots directly affects SOC contents, due to a larger number of decayed roots providing a rich source of carbon for soil (Jobbagy and Jackson 2000). Returning litter is also an important carbon source of surface SOC and therefore topsoil contained more SOC (Aon and Colaneri 2001).

**Table 1: Physical properties of soils under Zabo farming system**

| Properties / Villages | Bulk Density | | Particle Density | | Maximum Water Holding Capacity | |
|---|---|---|---|---|---|---|
| | CS | FS | CS | FS | CS | FS |
| Kikurma | 0.85 | 0.58 | 1.17 | 1.07 | 65.95 | 33.6 |
| Losami | 0.82 | 0.62 | 1.42 | 0.92 | 63.97 | 39.8 |
| Tetsumi | 0.82 | 0.74 | 1.58 | 1.04 | 62.00 | 55.3 |
| Mean | 0.73±0.11 | | 1.2±0.25 | | 53.43±13.59 | |
| Monte-carlo test of significance($p\leq0.05$) | 0.001 | | 0.16 | | 0.000 | |

**Table 2: Chemical properties of soils under Zabo farming system.**

| Properties / Villages | pH | | Cation exchange capacity | | Soil organic carbon (%) | |
|---|---|---|---|---|---|---|
| | CS | FS | CS | FS | CS | FS |
| Kikurma | 5.66 | 4.3 | 8.99 | 18.1 | 2.60 | 3.07 |
| Losami | 5.21 | 4.8 | 7.37 | 13.6 | 2.07 | 3.64 |
| Tetsumi | 5.29 | 4.4 | 8.23 | 17.35 | 2.39 | 4.25 |
| Mean | 4.94±0.53 | | 12.27±4.74 | | 3.00±0.82 | |
| Monte-carlo test of significance($p \leq 0.05$) | 0.000 | | 0.001 | | 0.000 | |

*B. Available nutrients*

The result revealed that the available nitrogen (N) range was medium in cultivated soil of Zabo farming system (Table 3). The pond mud of 0.3- 0.6 m depth is a good sediment containing 0.32 to 4.77% organic C and is used as a valuable manure. The sediment is also rich in adsorbed $NH_4$- N and available P (Rao and Padmaja 2016). Nambiar (1994) reported an increase in accessible N content in soil as a result of FYM application. Several researchers found increased soil accessible N and P as a result of long-term application of organic manure (Motavalli and Miles 2002; Shahid *et al.,* 2013; Sanjay-Swami *et al.,* 2021). Integration of allied components like *Azolla* + fish with rice in lowland farming could provide wider scope for bio resources recycling (Singh and Sanjay-Swami, 2020). Likewise Rao and Padmaja (2016) also reported that in Aptani farming system, pig and poultry droppings, rice husk, kitchen waste, ash and weeds are incorporated to maintain the soil available nutrients. The status of available potassium was found to be medium to high in Zabo farming system. Organic sources of K such as farm slurry or FYM could increase the levels of available K faster than inorganic fertilizers (Alfaro *et al*., 2004; Sanjay-Swami, 2019).

**Table 3: Available nutrient status in the soils of Zabo farming system.**

| Properties / Villages | Available Nitrogen (kg/ha) | | Available Phosphorus (kg/ha) | | Available Potassium (kg/ha) | |
|---|---|---|---|---|---|---|
| | CS | FS | CS | FS | CS | FS |
| Kikurma | 363.05 | 298.7 | 31.45 | 28.39 | 255.8 | 150.2 |
| Losami | 332.5 | 226.9 | 23.1 | 17.31 | 263.7 | 125.2 |
| Tetsumi | 330.15 | 278.4 | 23.93 | 19.11 | 281.8 | 148.6 |
| Mean | 304.95±48.177 | | 23.88±5.36 | | 204.21±69.96 | |
| Monte-carlo test of significance($p \leq 0.05$) | 0.90 | | 0.000 | | 0.000 | |

## CONCLUSIONS

In the present study, BD (0.80-0.85), PD (1.1-1.6), MWHC (62-66%) were higher in cultivated soil (terrace and valley) of Zabo system than the hilltop forest soil which was used as a reference soil. The soil under Zabo farming system was found to be acidic in reaction (pH 4.3-5.6) and high in organic matter (2.2-3.6%). The available N (330-365 kg/ha), available P (23-33 kg/ha) and available K (255-285 kg/ha) were higher in cultivated soil i.e. terrace and valley soils, compared to hilltop forest soil under Zabo farming system. The study clearly indicated that the Zabo farming system improved the soil behaviour. Considerable improvement in available nutrients and organic matter as well as in-situ soil moisture conservation has been observed under this system in hilly eco-system.

## FUTURE SCOPE

On the basis of estimated soil properties, soil quality index can be developed which will help the farmers practicing Zabo farming system to maintain the soil health resulting in sustainability of the system and improving crop productivity.

**Acknowledgement.** The financial assistance provided by Central Agriculture University, Imphal for conducting the research is fully acknowledged.

**Conflict of interest.** None.

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**How to cite this article:** Shilpa Mohanty, Sanjay-Swami, N. Janaki Singh, A.K. Singh and Lala I.P. Ray (2023). Characterization of Soils under Zabo Farming System of Nagaland. *Biological Forum – An International Journal, 15*(9): 392-396.